IMAQ™

IMAQ PCI/PXI™-1411 User Manual

Single-Channel Color Image Acquisition Board for PCI, PXI, and CompactPCI Chassis

NATIONAL INSTRUMENTS™

November 2000 Edition
Part Number 322157C-01

Worldwide Technical Support and Product Information

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Compliance

FCC/Canada Radio Frequency Interference Compliance*

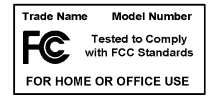
Determining FCC Class

The Federal Communications Commission (FCC) has rules to protect wireless communications from interference. The FCC places digital electronics into two classes. These classes are known as Class A (for use in industrial-commercial locations only) or Class B (for use in residential or commercial locations). Depending on where it is operated, this product could be subject to restrictions in the FCC rules. (In Canada, the Department of Communications (DOC), of Industry Canada, regulates wireless interference in much the same way.)

Digital electronics emit weak signals during normal operation that can affect radio, television, or other wireless products. By examining the product you purchased, you can determine the FCC Class and therefore which of the two FCC/DOC Warnings apply in the following sections. (Some products may not be labelled at all for FCC, if so the reader should then assume these are Class A devices.)

FCC Class A products only display a simple warning statement of one paragraph in length regarding interference and undesired operation. Most of our products are FCC Class A. The FCC rules have restrictions regarding the locations where FCC Class A products can be operated.

FCC Class B products display either a FCC ID code, starting with the letters **EXN**, or the FCC Class B compliance mark that appears as shown here on the right.



The curious reader can consult the FCC web site `http://www.fcc.gov` for more information.

FCC/DOC Warnings

This equipment generates and uses radio frequency energy and, if not installed and used in strict accordance with the instructions in this manual and the CE Mark Declaration of Conformity**, may cause interference to radio and television reception. Classification requirements are the same for the Federal Communications Commission (FCC) and the Canadian Department of Communications (DOC).

Changes or modifications not expressly approved by National Instruments could void the user's authority to operate the equipment under the FCC Rules.

Class A

Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Canadian Department of Communications

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

Class B

Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful

interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Canadian Department of Communications

This Class B digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe B respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

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Readers in the EU/EEC/EEA must refer to the Manufacturer's Declaration of Conformity (DoC) for information** pertaining to the CE Mark compliance scheme. The Manufacturer includes a DoC for most every hardware product except for those bought for OEMs, if also available from an original manufacturer that also markets in the EU, or where compliance is not required as for electrically benign apparatus or cables.

* Certain exemptions may apply in the USA, see FCC Rules §15.103 **Exempted devices**, and §15.105(c). Also available in sections of CFR 47.

** The CE Mark Declaration of Conformity will contain important supplementary information and instructions for the user or installer.

Conventions

The following conventions are used in this manual:

♦ The ♦ symbol indicates that the following text applies only to a specific product, a specific operating system, or a specific software version.

This icon denotes a note, which alerts you to important information.

This icon denotes a warning, which advises you of precautions to take to avoid being electrically shocked.

italic Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text that is a placeholder for a word or value that you must supply.

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1 Introduction

This chapter describes the PCI/PXI-1411 and describes your software programming choices.

About the PCI/PXI-1411

The PCI/PXI-1411 is a highly flexible monochrome and color IMAQ board for PCI, PXI, or CompactPCI chassis that supports a diverse range of analog cameras from many camera companies. The PCI/PXI-1411 acquires images in real time and can store these images in onboard frame memory, or transfer these images directly to system memory.

The PCI/PXI-1411 is simple to configure so that you can easily install the board and begin acquiring images. The PCI/PXI-1411 ships with NI-IMAQ, the National Instruments complete IMAQ driver software you can use to directly control the PCI/PXI-1411 and other National Instruments IMAQ hardware products. Using NI-IMAQ, you can quickly and easily start your applications without having to program the board at the register level.

The PCI/PXI-1411 features a precision color analog video decoder ideal for both industrial and scientific environments. The 1411 device supports both NTSC and PAL color standards as well as the RS-170 and CCIR monochrome standards. The 1411 also provides one external I/O line that you can use as a trigger or as a digital input/output (I/O) line. If you require more advanced triggering or digital I/O lines, you can use the PCI/PXI-1411 and NI-IMAQ with the National Instruments data acquisition (DAQ) product line.

Detailed specifications of the PCI/PXI-1411 are in Appendix A, *Specifications*.

Using PXI with CompactPCI

Using PXI-compatible products with standard CompactPCI products is an important feature provided by the *PXI Specification*, Revision 1.0. If you use a PXI-compatible plug-in device in a standard CompactPCI chassis, you will be unable to use PXI-specific functions, but you can still use the basic plug-in device functions.

The CompactPCI specification permits vendors to develop sub-buses that coexist with the basic PCI interface on the CompactPCI bus. Compatible operation is not guaranteed between CompactPCI devices with different sub-buses nor between CompactPCI devices with sub-buses and PXI. The standard implementation for CompactPCI does not include these sub-buses. Your PXI-1411 device will work in any standard CompactPCI chassis adhering to the *PICMG 2.0 R2.1 CompactPCI* core specification.

Software Programming Choices

Using NI-IMAQ, the National Instruments image acquisition driver software, you can program your IMAQ board to acquire and save images. You can use NI-IMAQ with other National Instruments software for a complete image acquisition and analysis solution, as shown in Figure 1-1.

NI-IMAQ works with LabVIEW and LabWindows/CVI, as well as conventional programming languages. National Instruments IMAQ Vision adds powerful image processing and analysis to these programming environments. You can also use IMAQ Vision Builder to quickly and easily prototype your IMAQ image analysis applications.

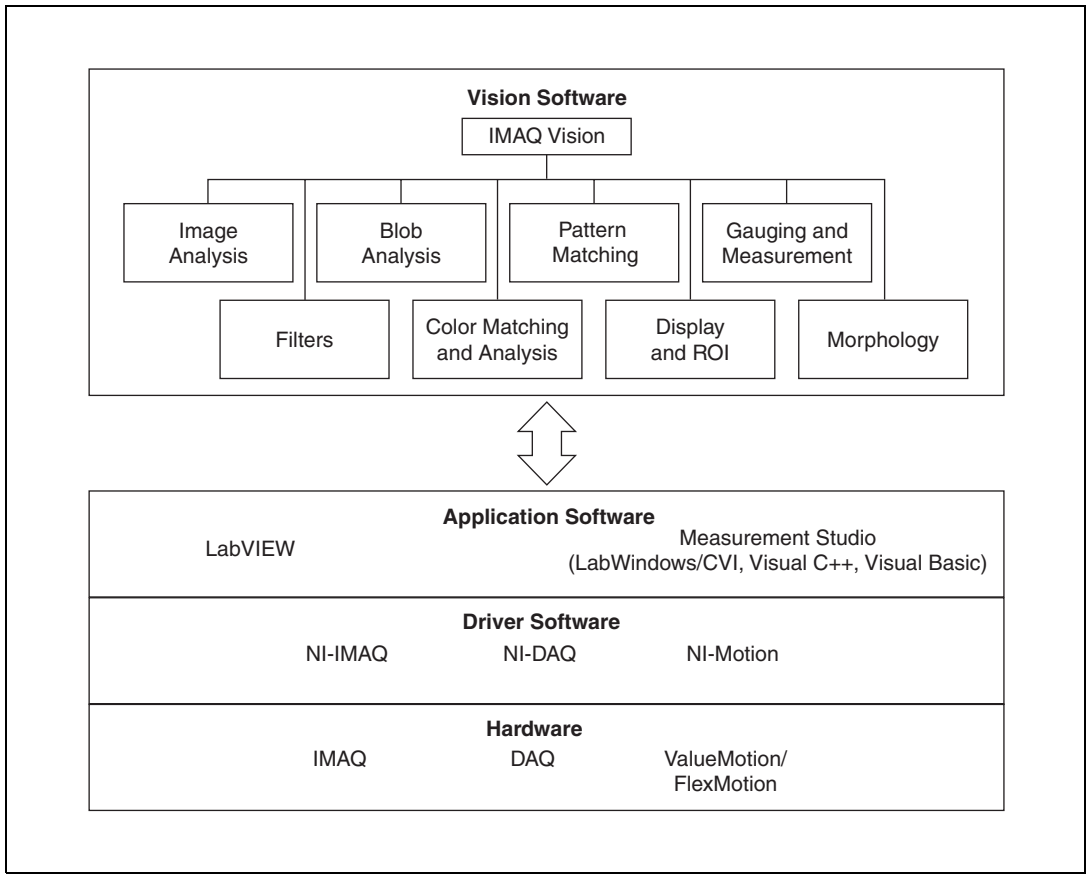

Figure 1-1. The Relationship between the Programming Environment, NI-IMAQ, and Your Hardware

NI-IMAQ Driver Software

The NI-IMAQ driver software is included with your IMAQ device. NI-IMAQ has an extensive library of functions that you can call from your application programming environment. These functions include routines for video configuration, image acquisition (continuous and single-shot), memory buffer allocation, trigger control, and board configuration, as shown in Figure 1-2.

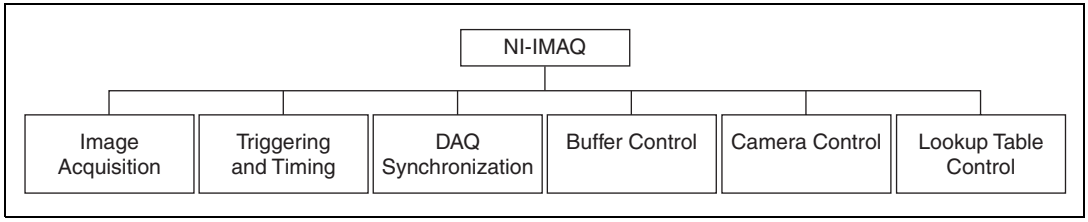

Figure 1-2. NI-IMAQ Functions

The NI-IMAQ driver software performs all of the functions required for acquiring and saving images. The NI-IMAQ software does not perform any image analysis. For image analysis functionality, refer to the *National Instruments IMAQ Vision* section in this chapter.

NI-IMAQ has both high-level and low-level functions for maximum flexibility and performance. Examples of high-level functions include the functions to acquire images in single-shot or continuous mode. An example of a low-level function is configuring an image sequence, since it requires advanced understanding of your IMAQ device and image acquisition.

NI-IMAQ internally resolves many of the complex issues between the computer and your IMAQ device, such as programming interrupts and DMA controllers.

NI-IMAQ is also the interface path between LabVIEW, LabWindows/CVI, or a conventional programming environment and your IMAQ device. The NI-IMAQ software kit includes a series of libraries for image acquisition for LabVIEW and Measurement Studio, which contains libraries for LabWindows/CVI, Visual C++, and Visual Basic. These libraries are functionally equivalent to the NI-IMAQ software.

National Instruments IMAQ Vision

IMAQ Vision is an image acquisition, processing, and analysis library of more than 200 functions for grayscale, color, and binary image display, image processing, pattern matching, shape matching, blob analysis, gauging, and measurement.

You can use IMAQ Vision functions directly or in combination for unique image processing. With IMAQ Vision you can acquire, display, manipulate, and store images as well as perform image analysis, processing, and interpretation. Using IMAQ Vision, an imaging novice or expert can perform graphical programming of the most basic or complicated image applications without knowledge of any algorithm implementations.

IMAQ Vision is available for LabVIEW and Measurement Studio, which includes support for LabWindows/CVI, Visual C++, and Visual Basic.

IMAQ Vision Builder

IMAQ Vision Builder is an interactive prototyping tool for machine vision and scientific imaging developers. With IMAQ Vision Builder, you can prototype vision software quickly or test how various vision image processing functions work.

As shown in Figure 1-3, IMAQ Vision Builder generates a Builder file, which is a text description that contains a recipe of the machine vision and image processing functions. This Builder file provides a guide you can use for developing applications with IMAQ Vision in LabVIEW or Measurement Studio.

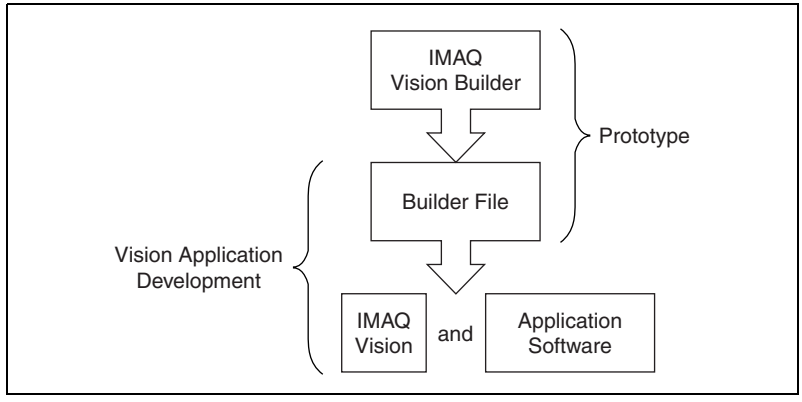

Figure 1-3. IMAQ Vision Builder and Application Development Tools

Integration with DAQ

Any platform that supports NI-IMAQ also supports NI-DAQ and a variety of National Instruments DAQ boards, allowing your IMAQ device and NI-IMAQ development to integrate with National Instruments DAQ products.

Vision and Motion

With National Instruments IMAQ hardware and IMAQ Vision pattern matching software, you can quickly and accurately locate objects in instances where objects vary in size, orientation, focus, and even when the part is poorly illuminated. Use National Instruments high-performance stepper and servo motion control products with pattern matching software for inspection and guidance applications such as locating alignment markers on semiconductor wafers, guiding robotic arms, inspecting the quality of manufactured parts, and locating cells.

2

Installation

This chapter lists what you need to get started acquiring images with your IMAQ device; describes optional equipment and custom cables; and explains how to unpack, configure, and install your IMAQ device.

What You Need to Get Started

To set up and use your PCI/PXI-1411, you will need the following:

- ❑ One of the following IMAQ devices:
  - PCI-1411
  - PXI-1411
- ❑ *Getting Started with Your IMAQ System*
- ❑ *IMAQ PCI/PXI-1411 User Manual*
- ❑ NI-IMAQ release notes
- ❑ NI-IMAQ for Windows 2000/NT/Me/9*x* and documentation
- ❑ Optional software packages and documentation:
  - IMAQ Vision for LabVIEW or Measurement Studio (LabWindows/CVI, Visual C++, Visual Basic)
  - LabVIEW
  - Measurement Studio (LabWindows/CVI, Tools for Visual Basic)
  - IMAQ Vision Builder
- ❑ BNC cable (included with your PCI/PXI-1411)
- ❑ S-Video cable (optional)
- ❑ Your Pentium-based PCI computer, PXI chassis, or CompactPCI chassis running Windows 2000, Windows NT, Windows Me, or Windows 9*x*
- ❑ An analog video camera (composite or S-Video)

Optional Equipment

National Instruments offers a variety of products for use with your PCI/PXI-1411, including other National Instruments DAQ devices for enhanced triggering, timing, or input/output.

For more specific information about these products, refer to your National Instruments catalogue or Web site, or call the office nearest you.

How to Set up Your IMAQ System

Use Figure 2-1 as a guide while you install your software and hardware, configure your hardware, and begin using NI-IMAQ in your application programs.

Follow the instructions in the *Getting Started with Your IMAQ System* document to install your NI-IMAQ software and IMAQ hardware.

If you will be accessing the NI-IMAQ device drivers through LabVIEW, you should read the NI-IMAQ release notes and the *NI-IMAQ User Manual* to help you get started.

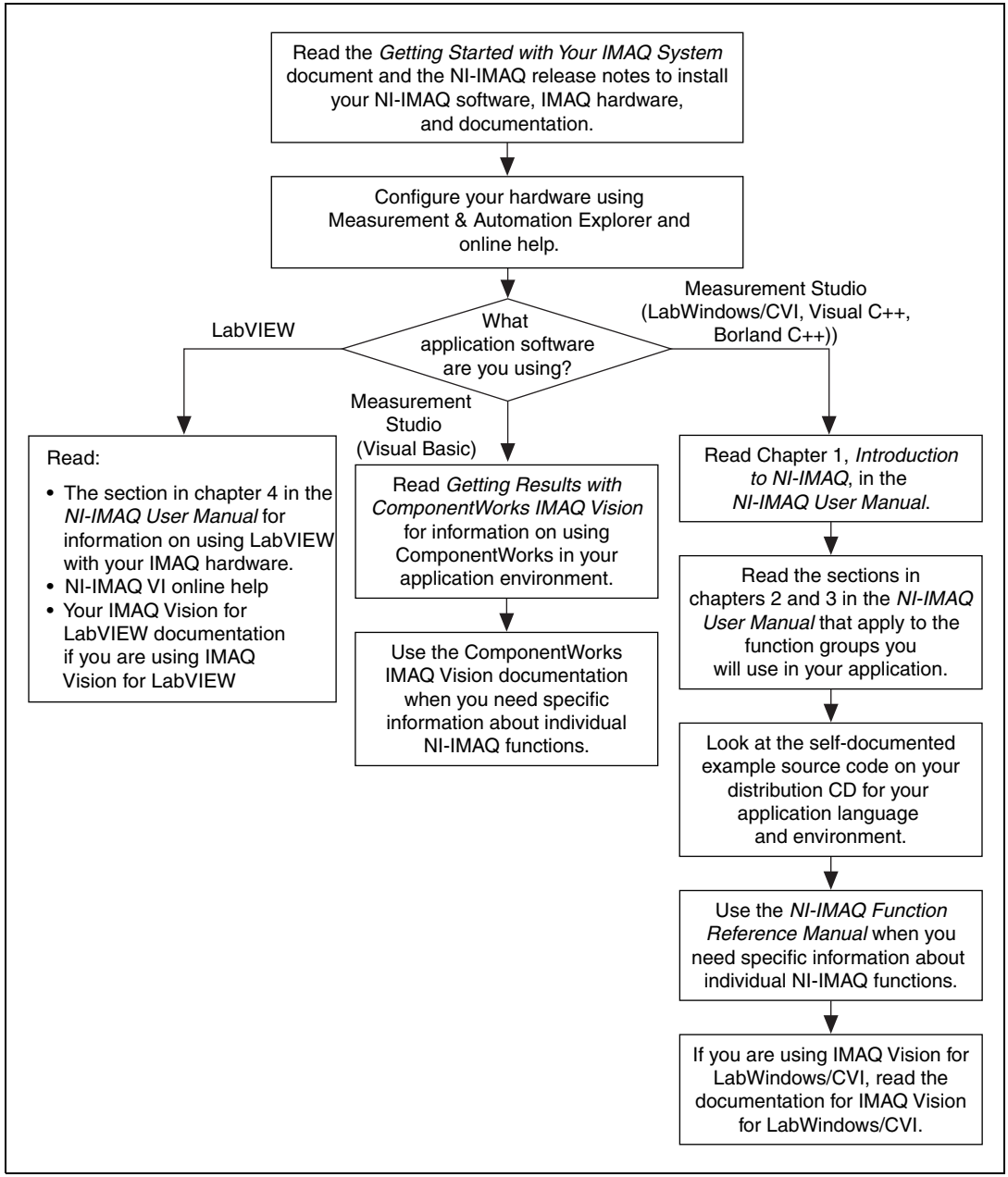
Read the *Getting Started with Your IMAQ System* document and the NI-IMAQ release notes to install your NI-IMAQ software, IMAQ hardware, and documentation.
Configure your hardware using Measurement & Automation Explorer and online help.
What application software are you using?
LabVIEW
Measurement Studio (Visual Basic)
Measurement Studio (LabWindows/CVI, Visual C++, Borland C++))
Read:
• The section in chapter 4 in the *NI-IMAQ User Manual* for information on using LabVIEW with your IMAQ hardware.
• NI-IMAQ VI online help
• Your IMAQ Vision for LabVIEW documentation if you are using IMAQ Vision for LabVIEW
Read *Getting Results with ComponentWorks IMAQ Vision* for information on using ComponentWorks in your application environment.
Use the ComponentWorks IMAQ Vision documentation when you need specific information about individual NI-IMAQ functions.
Read Chapter 1, *Introduction to NI-IMAQ*, in the *NI-IMAQ User Manual*.
Read the sections in chapters 2 and 3 in the *NI-IMAQ User Manual* that apply to the function groups you will use in your application.
Look at the self-documented example source code on your distribution CD for your application language and environment.
Use the *NI-IMAQ Function Reference Manual* when you need specific information about individual NI-IMAQ functions.
If you are using IMAQ Vision for LabWindows/CVI, read the documentation for IMAQ Vision for LabWindows/CVI.

Figure 2-1. How to Set up Your IMAQ System

Unpacking

Your PCI/PXI-1411 is shipped in an antistatic package to prevent electrostatic damage to the board. Electrostatic discharge can damage several components on the board. To avoid such damage in handling the board, take the following precautions:

- Ground yourself via a grounding strap or by holding a grounded object.
- Touch the antistatic package to a metal part of your computer chassis before removing the board from the package.
- Remove the board from the package and inspect the board for loose components or any other signs of damage. Notify National Instruments if the board appears damaged in any way. Do *not* install a damaged board in your computer.
- *Never* touch the exposed pins of connectors.

Installation

Note You must install the NI-IMAQ driver software before installing your 1411 device. For information on how to install NI-IMAQ, please see the *Getting Started with Your IMAQ System* document and your NI-IMAQ release notes.

- PCI-1411

  You can install the PCI-1411 in any available PCI expansion slot in your computer. However, to achieve the best noise performance, leave as much room as possible between the PCI-1411 and other boards and hardware. The following are general instructions, but consult your computer user manual or technical reference manual for specific instructions and warnings.

  1. Turn off and unplug your computer.

Warning To protect both yourself and the computer from electrical hazards, the computer should remain off until you finish installing the PCI-1411.

  2. Follow the electrostatic discharge guidelines in the *Unpacking* section of this chapter.
  3. Remove the cover of your computer.
  4. Make sure there are no lighted LEDs on your motherboard. If any are lit, wait until they go out before continuing your installation.

5. Touch the metal part of the power supply case inside the computer to discharge any static electricity that might be on your clothes or body.
6. Select any available PCI expansion slot.
7. Locate the metal bracket that covers the cut-out in the back panel of the chassis for the slot you have selected. Remove and save the bracket-retaining screw and the bracket cover.
8. Line up the PCI-1411 with the BNC connectors near the cut-out on the back panel. Slowly push down on the top of the PCI-1411 until its card-edge connector is resting on the expansion slot receptacle. Using slow, evenly distributed pressure, press the PCI-1411 straight down until it seats in the expansion slot.
9. Reinstall the bracket-retaining screw to secure the PCI-1411 to the back panel rail.
10. Visually verify the installation.
11. Replace the computer cover.

Your PCI-1411 is now installed.

- PXI-1411

You can install a PXI-1411 in any available 5 V peripheral slot in your PXI or CompactPCI chassis.

1. Turn off and unplug your PXI or CompactPCI chassis.
2. Choose an unused PXI or CompactPCI 5 V peripheral slot. Install the PXI-1411 in a slot that supports bus arbitration or bus-master cards. PXI-compliant chassis must have bus arbitration for all slots.
3. Remove the filler panel for the peripheral slot you have chosen.
4. Touch a metal part on your chassis to discharge any static electricity that might be on your clothes or body.
5. Insert the PXI-1411 in the selected 5 V slot. Use the injector/ejector handle to fully inject the device into place.
6. Screw the front panel of the PXI-1411 to the front panel mounting rails of the PXI or CompactPCI chassis.
7. Visually verify the installation.
8. Plug in and turn on the PXI or CompactPCI chassis.

Your PXI-1411 is now installed.

3

Hardware Overview

This chapter presents an overview of the hardware functions on your PCI/PXI-1411 board and explains the operation of each functional unit making up the PCI/PXI-1411.

Functional Overview

The PCI/PXI-1411 features a flexible, high-speed data path optimized for the acquisition and formatting of video data from analog monochrome and color cameras.

The block diagram in Figure 3-1 illustrates the key functional components of the PCI/PXI-1411.

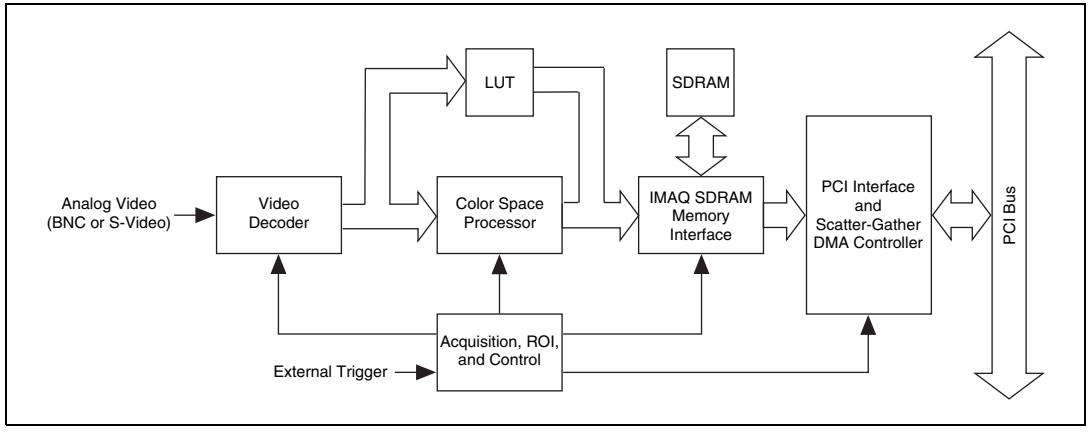

Figure 3-1. PCI/PXI-1411 Block Diagram

Video Acquisition

The PCI/PXI-1411 can acquire analog color video in a variety of modes and store the images in the onboard SDRAM memory or transfer the images directly to PCI system memory.

Video Decoder

The PCI/PXI-1411 supports NTSC and PAL video standards in either composite or S-Video format. The onboard video decoder converts the incoming video signal to Red, Green, and Blue (RGB) data and passes this data to the color-space processor for further processing.

The video decoder also allows you to control numerous parameters to optimize an acquisition. You can independently adjust parameters such as analog input range, brightness, contrast, saturation, or frequency range (controlled by different filters). See the Measurement & Automation Explorer online help for a complete description of the PCI/PXI-1411 video parameters.

Furthermore, the video decoder strips out all necessary clock and synchronization signals included in the video signal and controls the acquisition conditions automatically. High-quality circuitry regenerates even bad timing signals allowing acquisitions from, for example, a video cassette recorder (VCR).

Note The IMAQ PCI-1411 revision C, IMAQ PXI-1411 revision A, and all later revisions are factory calibrated to improve measurement accuracy and board-to-board consistency. Specifically, the luma gain and chroma gain have been calibrated. See Appendix A, *Specifications*, for accuracy specifications.

Color-Space Processor and LUTs

The color-space processor receives the RGB data from the video decoder and performs several different (optional) operations on the data before passing them to the memory controller. Processing functions include the following:

- Adjusting independent gain of the three signals (R, G, and B). You can use independent gain to perform, for example, white balancing on the acquired image.
- Applying three independent look-up tables (LUTs) to the R, G, and B data.
- Converting the RGB data into Hue, Saturation, and Luminance (HSL).
- Processing the hue plane to clear pixels where the saturation falls below a predefined threshold value. This function is called *post-decoding coring*. You can use this function to remove part of the image without color information (monochrome) that otherwise would introduce noise on the hue plane.

The color-space processor can export the video data in 32-bit RGB or HSL formats or in individual 8-bit hue, saturation, or luminance planes. For more information on these image types, see the *Image Representations* section in Appendix B, *Introduction to Color*.

SDRAM

The PCI/PXI-1411 comes with 16 MB of onboard high-speed synchronous dynamic RAM (SDRAM). The PCI/PXI-1411 can use the onboard RAM as a first-in first-out (FIFO) buffer, transferring the image data as it is acquired or acquiring the image data into SDRAM and holding it for later transfer to main memory.

Trigger Control and Mapping Circuitry

The trigger control monitors and drives the external trigger line. You can configure this line to start an acquisition on a rising or falling edge and drive the line asserted or unasserted, similar to a digital I/O line. You can also map many of the PCI/PXI-1411 status signals to this trigger line and program the trigger line in polarity and direction. For a list of mappable status signals, see Chapter 3, *Programming with NI-IMAQ*, of the *NI-IMAQ User Manual*.

Acquisition, Scaling, ROI

The acquisition, scaling, and region-of-interest (ROI) circuitry monitors the incoming video signals and routes the active pixels to the SDRAM memory. The PCI/PXI-1411 can perform ROI and scaling on all video lines and frames. Pixel and line scaling transfers certain multiples (two, four, or eight) of pixels and lines to onboard memory. In an ROI acquisition, you select an area within the acquisition window to transfer to the PCI bus.

Scatter-Gather DMA Controllers

The PCI/PXI-1411 uses three independent onboard direct memory access (DMA) controllers. The DMA controllers transfer data between the onboard SDRAM memory buffers and the PCI bus. Each of these controllers supports scatter-gather DMA, which allows the DMA controller to reconfigure on-the-fly. Thus, the PCI/PXI-1411 can perform continuous image transfers directly to either contiguous or fragmented memory buffers.

Bus Master PCI Interface

The PCI/PXI-1411 implements the PCI interface with a National Instruments custom application-specific integrated circuit (ASIC), the PCI MITE. The PCI interface can transfer data at a maximum rate of 132 Mbytes/s in bus master mode. The PCI/PXI-1411 can generate 8-, 16-, and 32-bit memory read and write cycles, both single and multiple. In slave mode, the PCI/PXI-1411 is a medium-speed decoder that accepts both memory and configuration cycles. The interface logic ensures that the PCI/PXI-1411 can meet PCI loading, driving, and timing requirements.

Board Configuration NVRAM

The PCI/PXI-1411 contains onboard nonvolatile RAM (NVRAM) that configures all registers on power-up.

Start Conditions

The PCI/PXI-1411 can start acquisitions in a variety of conditions:

- Software control—The PCI/PXI-1411 supports software control of acquisition start. You can configure the PCI/PXI-1411 to capture a fixed number of fields or frames. Use this configuration for capturing a single frame or a sequence of frames.
- Trigger control—You can start an acquisition by enabling the external trigger line. This input can start a video acquisition on a rising or falling edge.
- Frame/field selection—With an interlaced camera and the PCI/PXI-1411 in frame mode, you can program the PCI/PXI-1411 to start an acquisition on any odd or even field.

Acquisition Window Control

You can configure numerous parameters on the PCI/PXI-1411 to control the video acquisition window. A brief description of each parameter follows:

- Acquisition window—The PCI/PXI-1411 allows you to specify a particular region of active pixels and active lines within the incoming video data. The active pixel region selects the starting pixel and number of pixels to be acquired relative to the assertion edge of the horizontal (or line) enable signal from the camera. The active line region selects the starting line and number of lines to be acquired relative to the assertion edge of the vertical (or frame) enable signal.

- Region of interest—The PCI/PXI-1411 uses a second level of active pixel and active line regions for selecting a region of interest. When you disable the region-of-interest circuitry, the board stores the entire acquisition window into onboard or system memory. However, when you enable the region-of-interest circuitry, the board acquires only a selected subset of the image frame.
- Scaling down—The scaling down circuitry also controls the active acquisition region. The PCI/PXI-1411 can scale down a frame by reducing the number of pixels per line, the number of lines per frame, or both. For active pixel selection, the PCI/PXI-1411 can select every pixel, every other pixel, every fourth pixel, or every eighth pixel. For active line selection, the PCI/PXI-1411 can select every line, every other line, every fourth line, or every eighth line. You can use the scaling down circuitry in conjunction with the region-of-interest circuitry.

4

Signal Connections

This chapter describes cable connections for the PCI/PXI-1411.

I/O Connector

The PCI/PXI-1411 uses one S-Video and two BNC connectors on the front panel to connect to video data inputs and the external trigger signal. Figure 4-1 shows the position of the three connectors.

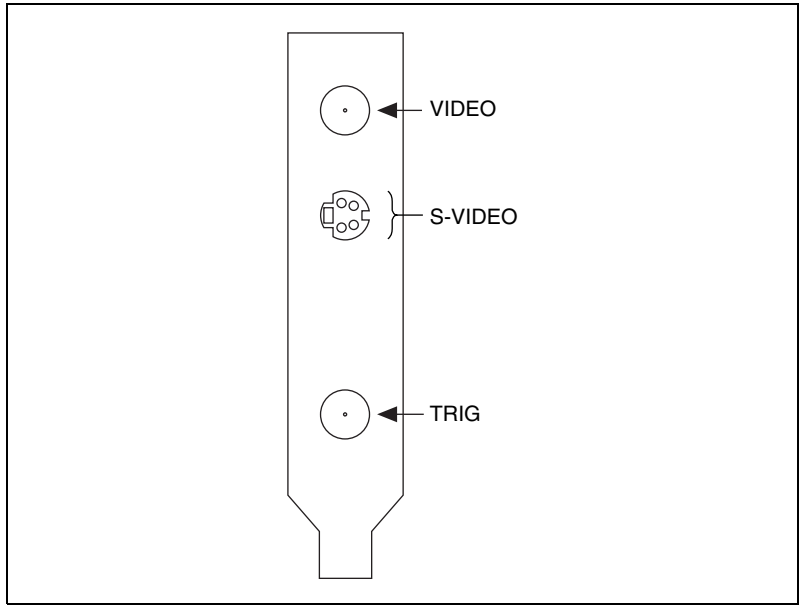

Figure 4-1. PCI/PXI-1411 Connectors

Signal Description

Table 4-1 describes each signal connection on the 1411 device connectors:

Table 4-1. I/O Connector Signals

Signal Name	Description
VIDEO	Composite Video—The signal allows you to make a referenced single-ended (RSE) connection to the video channel.
S-VIDEO	S-Video—A connector composed of two signals, as follows: Y—The Y signal of the S-Video connection contains the luma and synchronization information of the video signal. C—The C signal of the S-Video connection contains the chroma information of the video signal.
TRIG	External trigger—A TTL I/O line you can use to start an acquisition or to control external events. You can program the triggers to be rising or falling edge sensitive. You can also program the triggers to be programmatically asserted or unasserted similar to the function of a digital I/O line or to contain internal status signals (by using the onboard events). For a list of mappable status signals, see Chapter 3, *Programming with NI-IMAQ*, of the *NI-IMAQ User Manual*.
GND	Ground—A direct connection to digital ground on the PCI/PXI-1411.

Custom Cables

If you plan to make your own cables, refer to Figure 4-2 for the pin-out of the S-Video connector, as seen from the front of the PCI/PXI-1411.

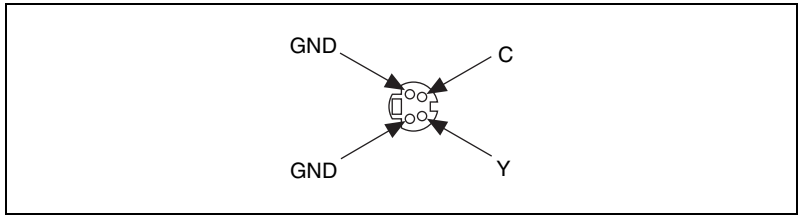

Figure 4-2. S-Video Connector Pin Assignments

A

Specifications

This appendix lists the specifications of the PCI/PXI-1411. These specifications are typical at 25 °C, unless otherwise stated.

Formats Supported

Input formats

- RS-170/NTSC ..... 29.97 frames/s
- CCIR/PAL ..... 25 frames/s

Output formats

- RGB 32-bit
- HSL 32-bit
- R, G, B, H, S, or L 8-bit
- Pixel aspect ratio ..... Square pixel

Video Input

Quantity ..... 1 (VIDEO)

VIDEO ..... Composite video on BNC (RSE), Y/C on S-Video connector (RSE)

Input impedance ..... 75 Ω ± 1%

Input range (blank to white) ..... 700 mV (calibrated) or 400 mV to 1.00 V (variable gain) (PCI-1411 revision C and later, PXI-1411 revision A and later)

Frequency response (luminance)

- Full range ..... 12 MHz (–3 dB) typ (all filters off)
- Programmable ..... Decimation and lowpass filters

Accuracy

Absolute accuracy[1]

- Luma gain ..... ± 2.5% of reading
- Chroma gain ..... ± 2.5% of reading
- Temperature drift ..... <250 ppm/°C

A/D Conversion

Quantity ..... One 8-bit 2X oversampling for composite video
Two 8-bit 2X oversampling for Y/C (S-Video)

Dynamic range ..... 46 dB typ

Sampling Frequency

- RS-170/NTSC ..... 27.54 MHz (double rate of square pixel
- CCIR/PAL ..... 29.5 MHz (double rate of square pixel)

Color Decoding

Composite video

- Luma path ..... Chroma trap filter and/or line comb
- Chroma path ..... Bandpass filter and/or line comb

Memory

Onboard memory ..... 16 MB synchronous dynamic RAM

LUTs ..... Three 256 × 8 (RGB only)

---

[1] Calibration conditions:
White level 700 mV
Contrast 1.00
Saturation 1.00
Brightness 1.00
Luma bandwidth Full
Ambient temperature 25 °C nominal

External Connections

Trigger sense ..... TTL

Trigger level ..... Programmable (rising or falling)

PCI Interface

PCI initiator (master) capability ..... Supported

PCI target (slave) capability ..... Supported

Data path ..... 32 bits

Board voltage ..... 5 V, 12 V, –12 V

Board type ..... 32-bit half-size card

Parity generation/checking,
error reporting ..... Supported

Target decode speed ..... Medium (1 clock)

Target fast back-to-back capability ..... Supported

Resource locking ..... Supported as a master and slave

PCI interrupts ..... Interrupts passed on INTA# signal

Base address registers ..... BAR0 (16 KB)
BAR1 (64 KB)

Expansion ROM ..... 4 KB

PCI master performance

- Ideal ..... 133 Mbytes/s
- Sustained ..... 100 Mbytes/s

Power Requirements

Voltage ..... +5 V (1.00 A)
+12 V (75 mA)

Physical

Dimensions

PCI-1411.....10.7 by 17.5 cm (4.2 by 6.9 in.)

PXI-1411 .....10 by 16 cm (3.9 by 6.3 in.)

Weight

PCI-1411.....0.136 kg (0.3 lb)

PXI-1411 .....0.154 kg (0.34 lb)

Environment

Operating temperature ..... 0–55 °C

Storage temperature.....–20–70 °C

Relative humidity .....5–90%, noncondensing

MTBF .....839,653 h at 30 °C

Emissions.....EN 55011:1991 Group 1 Class A at 10 m FCC Class A at 10 m

Functional shock (PXI only).....MIL-T-28800 E Class 3 (per Section 4.5.5.4.1) Half-sine shock pulse, 11 ms duration, 30 g peak, 30 shocks per face

Operational random vibration (PXI only).....5 to 500 Hz, 0.31 grms, 3 axes

Nonoperational random vibration (PXI only).....5 to 500 Hz, 2.5 grms, 3 axes

Note Random vibration profiles were developed in accordance with MIL-T-28800E and MIL-STD-810E Method 514. Test levels exceed those recommended in MIL-STD-810E for Category 1 (Basic Transportation, Figures 514.4-1 through 514.4-3).

B

Introduction to Color

Color is the wavelength of the light we receive in our eye when we look at an object. In theory, the color spectrum is infinite. Humans, however, can see only a small portion of this spectrum—the portion that goes from the red edge of infrared light (the longest wavelength) to the blue edge of ultraviolet light (the shortest wavelength). This continuous spectrum is called the visible spectrum, as shown in Figure B-1.

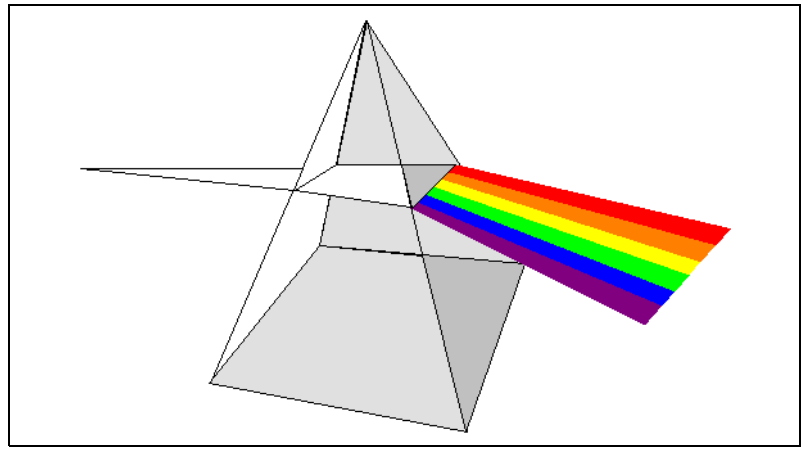

Figure B-1. White Light and the Visible Spectrum

White light is a combination of all colors at once. The spectrum of white light is continuous and goes from ultraviolet to infrared in a smooth transition. You can represent a good approximation of white light by selecting a few reference colors and weighting them appropriately. The most common way to represent white light is to use three reference components, such as red, green, and blue (R, G, and B primaries). You can simulate most colors of the visible spectrum using these primaries. For example, video projectors use red, green, and blue light generators, and an RGB camera uses red, green, and blue sensors.

The perception of a color depends on many factors, such as:

- *Hue*, which is the perceived dominant color. Hue depends directly on the wavelength of a color.
- *Saturation*, which is dependent on the amount of white light present in a color. Pastels typically have a low saturation while very rich colors have a high saturation. For example, pink typically has a red hue but has a low saturation.
- *Luminance*, which is the brightness information in the video picture. The luminance signal amplitude varies in proportion to the brightness of the video signal and corresponds exactly to the monochrome picture.
- *Intensity*, which is the brightness of a color and which is usually expressed as light or dark. For example, orange and brown may have the same hue and saturation; however, orange has a greater intensity than brown.

Image Representations

Color images can be represented in several different formats. These formats can contain all color information from the image or they can consist of just one aspect of the color information, such as hue or luminance. The following image representations can be produced using the PCI/PXI-1411.

RGB

The most common image representation is 32-bit RGB format. In this representation, the three 8-bit color planes—red, green and blue—are packed into an array of 32-bit integers. This representation is useful for displaying the image on your monitor. The 32-bit integer organized as:

0	RED	GREEN	BLUE

where the high-order byte is not used and blue is the low-order byte.

Color Planes

Each color plane can be returned individually. The red, green, or blue plane is extracted from the RGB image and represented as an array of 8-bit integers.

Hue, Saturation, Luminance, and Intensity Planes

The 8-bit hue, saturation, luminance, and intensity planes can also be returned individually if you want to analyze the image.

Luminance, Intensity, Hue, or Saturation are defined using the Red, Green, and Blue values in the following formulas:

Luminance = $0.299 \times \text{Red} + 0.587 \times \text{Green} + 0.114 \times \text{Blue}$

Intensity = (Red + Green + Blue) / 3

Hue = ATN2 (Y, X)

where

Y = (Green - Blue) / $\sqrt{2}$ and

X = ($2 \times$ Red - Green - Blue) / $\sqrt{6}$

Saturation = $255 \times \left(1 - \frac{3 \times Min(R, G, B)}{R + G + B}\right)$

32-Bit HSL and HSI

You can also pack the three 8-bit Hue, Saturation, and Luminance planes (HSL) or the three Hue, Saturation, and Intensity planes (HSI) in one array of 32-bit integers, which is equivalent to the 32-bit RGB representation.

C

Technical Support Resources

Web Support

National Instruments Web support is your first stop for help in solving installation, configuration, and application problems and questions. Online problem-solving and diagnostic resources include frequently asked questions, knowledge bases, product-specific troubleshooting wizards, manuals, drivers, software updates, and more. Web support is available through the Technical Support section of `ni.com`

NI Developer Zone

The NI Developer Zone at `ni.com/zone` is the essential resource for building measurement and automation systems. At the NI Developer Zone, you can easily access the latest example programs, system configurators, tutorials, technical news, as well as a community of developers ready to share their own techniques.

Customer Education

National Instruments provides a number of alternatives to satisfy your training needs, from self-paced tutorials, videos, and interactive CDs to instructor-led hands-on courses at locations around the world. Visit the Customer Education section of `ni.com` for online course schedules, syllabi, training centers, and class registration.

System Integration

If you have time constraints, limited in-house technical resources, or other dilemmas, you may prefer to employ consulting or system integration services. You can rely on the expertise available through our worldwide network of Alliance Program members. To find out more about our Alliance system integration solutions, visit the System Integration section of `ni.com`

Worldwide Support

National Instruments has offices located around the world to help address your support needs. You can access our branch office Web sites from the Worldwide Offices section of `ni.com`. Branch office Web sites provide up-to-date contact information, support phone numbers, e-mail addresses, and current events.

If you have searched the technical support resources on our Web site and still cannot find the answers you need, contact your local office or National Instruments corporate. Phone numbers for our worldwide offices are listed at the front of this manual.

Glossary

Prefix	Meaning	Value
p-	pico-	10^{-12}
n-	nano-	10^{-9}
µ-	micro-	10^{-6}
m-	milli-	10^{-3}
k-	kilo-	10^{3}
M-	mega-	10^{6}
G-	giga-	10^{9}
t-	tera-	10^{12}

Numbers/Symbols

+	Positive of, or plus.
/	Per.
Ω	Ohm.
±	Plus or minus.
–	Negative of, or minus.

A

A	Amperes.
AC	Alternating current.
acquisition window	The image size specific to a video standard or camera resolution.
active line region	The region of lines actively being stored. Defined by a line start (relative to the vertical synchronization signal) and a line count.

active pixel region	The region of pixels actively being stored. Defined by a pixel start (relative to the horizontal synchronization signal) and a pixel count.
address	Value that identifies a specific location (or series of locations) in memory.
API	Application programming interface.
area	A rectangular portion of an acquisition window or frame that is controlled and defined by software.
array	Ordered, indexed set of data elements of the same type.
ASIC	Application-Specific Integrated Circuit. A proprietary semiconductor component designed and manufactured to perform a set of specific functions for specific customer needs.

B

b	Bit. One binary digit, either 0 or 1.
B	Byte. Eight related bits of data, an eight-bit binary number; also used to denote the amount of memory required to store one byte of data
brightness	A constant that is added to the red, green, and blue components of a color pixel during the color decoding process.
buffer	Temporary storage for acquired data.
bus	A group of conductors that interconnect individual circuitry in a computer, such as the PCI bus; typically the expansion vehicle to which I/O or other devices are connected.

C

C	Celsius.
cache	High-speed processor memory that buffers commonly used instructions or data to increase processing throughput.
CMOS	Complementary metal-oxide semiconductor.

color space	The mathematical representation for a color. For example, color can be described in terms of red, green, and blue; hue, saturation, and luma; or hue, saturation, and intensity.
composite video	A type of color video transmission where synchronization, luma, and chroma information are transmitted on one analog signal.
contrast	A constant multiplication factor applied to the luma and chroma components of a color pixel in the color decoding process.
coring	The process of eliminating color information in low-color situations (if the saturation is lower than a predefined value).
CPU	Central processing unit.

D

DAQ	Data acquisition. (1) Collecting and measuring electrical signals from sensors, transducers, and test probes or fixtures and inputting them to a computer for processing. (2) Collecting and measuring the same kinds of electrical signals with A/D or DIO boards plugged into a computer, and possibly generating control signals with D/A and/or DIO boards in the same computer.
dB	Decibel. The unit for expressing a logarithmic measure of the ratio of two signal levels: $dB = 20\log_{10} V1/V2$, for signals in volts.
DC	Direct current.
default setting	A default parameter value recorded in the driver; in many cases, the default input of a control is a certain value (often 0) that means *use the current default setting*.
DMA	Direct memory access. A method by which data can be transferred to and from computer memory from and to a device or memory on the bus while the processor does something else; DMA is the fastest method of transferring data to/from computer memory.
DRAM	Dynamic RAM.

drivers	Software that controls a specific hardware device, such as an image acquisition board.
dynamic range	The ratio of the largest signal level a circuit can handle to the smallest signal level it can handle (usually taken to be the noise level), normally expressed in decibels.

E

EEPROM	Electrically erasable programmable read-only memory. ROM that can be erased with an electrical signal and reprogrammed.
external trigger	A voltage pulse from an external source that triggers an event such as A/D conversion.

F

field	For an interlaced video signal, a field is half the number of horizontal lines needed to represent a frame of video. The first field of a frame contains all the odd-numbered lines, the second field contains all of the even-numbered lines.
FIFO	First-in first-out memory buffer. The first data stored is the first data sent to the acceptor; FIFOs are used on IMAQ devices to temporarily store incoming data until that data can be retrieved.
frame	A complete image. In interlaced formats, a frame is composed of two fields.
ft	Feet.

G

gamma	The nonlinear change in the difference between the video signal's brightness level and the voltage level needed to produce that brightness.
genlock	Circuitry that aligns the video timing signals by locking together the horizontal, vertical, and color subcarrier frequencies and phases and generates a pixel clock to clock pixel data into memory for display or into another circuit for processing.

H

h	Hour.
HSI	Color encoding scheme in Hue, Saturation, and Intensity.
HSL	Color encoding scheme using Hue, Saturation, and Luma information where each image in the pixel is encoded using 32 bits: 8 bits for hue, 8 bits for saturation, 8 bits for luma, and 8 unused bits.
HSYNC	Horizontal synchronization signal. The synchronization pulse signal produced at the beginning of each video scan line that keeps a video monitor's horizontal scan rate in step with the transmission of each new line.
hue	Represents the dominant color of a pixel. The hue function is a continuous function that covers all the possible colors generated using the R, G, and B primaries. *See also RGB*.
hue offset	The value added to all hue values so that the discontinuity occurs outside the values of interest during analysis.
Hz	Hertz. Frequency in units of 1/second.

I

I/O	Input/output. The transfer of data to/from a computer system involving communications channels, operator interface devices, and/or data acquisition and control interfaces.
IC	Integrated circuit.
IEEE	Institute of Electrical and Electronics Engineers.
IMAQ	Image acquisition.
in.	Inches.
instrument driver	A set of high-level software functions, such as NI-IMAQ, that control specific plug-in computer boards. Instrument drivers are available in several forms, ranging from a function callable from a programming language to a virtual instrument (VI) in LabVIEW.

intensity	The sum of the Red, Green, and Blue primaries divided by three: (Red + Green + Blue)/3.
interlaced	A video frame composed of two interleaved fields. The number of lines in a field are half the number of lines in an interlaced frame.
interrupt	A computer signal indicating that the CPU should suspend its current task to service a designated activity.
interrupt level	The relative priority at which a device can interrupt.
IRQ	Interrupt request. *See interrupt*.

K

k	Kilo. The standard metric prefix for 1,000, or 10^3, used with units of measure such as volts, hertz, and meters.
K	Kilo. The prefix for 1,024, or 2^{10}, used with B in quantifying data or computer memory.
kbytes/s	A unit for data transfer that means 1,000 or 10^3 bytes/s.
Kword	1,024 words of memory.

L

line count	The total number of horizontal lines in the picture.
LSB	Least significant bit.
luma	The brightness information in the video picture. The luma signal amplitude varies in proportion to the brightness of the video signal and corresponds exactly to the monochrome picture.
luminance	*See luma*.
LUT	Lookup table. Table containing values used to transform the gray-level values of an image. For each gray-level value in the image, the corresponding new value is obtained from the look-up table.

M

m	Meters.
M	(1) Mega, the standard metric prefix for 1 million or 10^6, when used with units of measure such as volts and hertz; (2) mega, the prefix for 1,048,576, or 2^{20}, when used with B to quantify data or computer memory.
MB	Megabyte of memory.
Mbytes/s	A unit for data transfer that means 1 million or 10^6 bytes/s.
memory buffer	*See buffer*.
memory window	Continuous blocks of memory that can be accessed quickly by changing addresses on the local processor.
MSB	Most significant bit.
MTBF	Mean time between failure.
mux	Multiplexer. A switching device with multiple inputs that selectively connects one of its inputs to its output.

N

NI-IMAQ	Driver software for National Instruments IMAQ hardware.
noninterlaced	A video frame where all the lines are scanned sequentially, instead of divided into two frames as in an interlaced video frame.
NTSC	National Television Standards Committee. The committee that developed the color video standard used primarily in North America, which uses 525 lines per frame. *See also PAL*.
NVRAM	Nonvolatile RAM. RAM that is not erased when a device loses power or is turned off.

O

operating system	Base-level software that controls a computer, runs programs, interacts with users, and communicates with installed hardware or peripheral devices.

P

PAL	Phase Alternation Line. One of the European video color standards; uses 625 lines per frame. *See also NTSC*.
PCI	Peripheral Component Interconnect. A high-performance expansion bus architecture originally developed by Intel to replace ISA and EISA. PCI offers a theoretical maximum transfer rate of 132 Mbytes/s.
pixel	Picture element. The smallest division that makes up the video scan line; for display on a computer monitor, a pixel's optimum dimension is square (aspect ratio of 1:1, or the width equal to the height).
pixel clock	Divides the incoming horizontal video line into pixels.
pixel count	The total number of pixels between two horizontal synchronization signals. The pixel count determines the frequency of the pixel clock.
PLL	Phase-locked loop. Circuitry that provides a very stable pixel clock that is referenced to another signal, for example, an incoming horizontal synchronization signal.
protocol	The exact sequence of bits, characters, and control codes used to transfer data between computers and peripherals through a communications channel.
pts	Points.

R

RAM	Random-access memory.
real time	A property of an event or system in which data is processed as it is acquired instead of being accumulated and processed at a later time.
relative accuracy	A measure in LSB of the accuracy of an ADC; it includes all nonlinearity and quantization errors but does not include offset and gain errors of the circuitry feeding the ADC.
resolution	The smallest signal increment that can be detected by a measurement system. Resolution can be expressed in bits, in proportions, or in percent of full scale. For example, a system has 12-bit resolution, one part in 4,096 resolution, and 0.0244 percent of full scale.

RGB	Color encoding scheme using red, green, and blue (RGB) color information where each pixel in the color image is encoded using 32 bits: 8 bits for red, 8 bits for green, 8 bits for blue, and 8 bits for the alpha value (unused).
ROI	Region of interest. A hardware-programmable rectangular portion of the acquisition window.
ROM	Read-only memory.
RS-170	The U.S. standard used for black-and-white television.
RSE	Referenced single-ended. All measurements are made with respect to a common reference measurement system or a ground. Also called a grounded measurement system.

S

s	Seconds.
S-Video	A type of color video transmission where timing and luma information are transmitted on one analog signal and chroma is transmitted on a separate analog signal.
saturation	The amount of white added to a pure color. Saturation relates to the richness of a color. A saturation of zero corresponds to a pure color with no white added. Pink is a red with low saturation.
scaling down circuitry	Circuitry that scales down the resolution of a video signal.
scatter-gather DMA	A type of DMA that allows the DMA controller to reconfigure on-the-fly.
SDRAM	Synchronous dynamic RAM.
SRAM	Static RAM.
sync	Tells the display where to put a video picture. The horizontal sync indicates the picture's left-to-right placement and the vertical sync indicates top-to-bottom placement.
system RAM	RAM installed on a personal computer and used by the operating system, as contrasted with onboard RAM.

T

transfer rate	The rate, measured in bytes/s, at which data is moved from source to destination after software initialization and set up operations. The maximum rate at which the hardware can operate.
trigger	Any event that causes or starts some form of data capture.
trigger control and mapping circuitry	Circuitry that routes, monitors, and drives external and RTSI bus trigger lines. You can configure each of these lines to start or stop acquisition on a rising or falling edge.
TTL	Transistor-transistor logic.

V

VCO	Voltage-controlled oscillator. An oscillator that changes frequency depending on a control signal; used in a PLL to generate a stable pixel clock.
VI	Virtual Instrument. (1) A combination of hardware and/or software elements, typically used with a PC, that has the functionality of a classic stand-alone instrument (2) A LabVIEW software module (VI), which consists of a front panel user interface and a block diagram program.
VSYNC	Vertical synchronization signal. The synchronization pulse generated at the beginning of each video field that tells the video monitor when to start a new field.

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